CONFERENCE ON DISARMAMENT

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PROGRESS REPORT TO THE CONFERENCE ON DISARMAMENT ON THE FORTY-THIRD SESSION OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL CO-OPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

1. The Ad Hoc Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events (GSE), initially established in pursuance of the decision taken by the Conference of the Committee on Disarmament on 22 July 1976, held its forty-third formal session from 12 to 23 February 1996, in the Palais des Nations, Geneva, under the Chairmanship of Dr. Ola Dahlman, Sweden. This was the thirty-fifth session of the Group convened under its new mandate by the decision of the Committee on Disarmament at its 48th meeting on 7 August 1979.

2. The Ad Hoc Group is open to all Member States of the Conference on Disarmament. It is also open on a standing basis to all non-Member States which have been invited upon their request by the Conference on Disarmament to participate in its work. Accordingly, scientific experts and representatives of the following Member States of the Conference on Disarmament participated in the session: Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, China, Egypt, France, Germany, Hungary, Iran (Islamic Republic of), Italy, Japan, Mongolia, the Netherlands, Poland, the Russian Federation, Sweden, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

3. Scientific experts and representatives from the following non-Member States of the Conference on Disarmament participated in the session: Austria, the Czech Republic, Denmark, Finland, Israel, Kazakstan, Norway, the Republic of Korea, the Republic of South Africa, Spain, Switzerland, Turkey and Ukraine.

4. During the session 51 papers concerning national investigations related to the work of the Ad Hoc Group were presented by participating experts and reviewed by the Group.

5. The main topic of the session was the evaluation of the first full year of the Group of Scientific Experts Third Technical Test (GSETT-3). The Ad Hoc Group reviewed and finalized a comprehensive report on the first year of experience from this test, based upon a draft report provided by the GSETT-3 Working Group on Evaluation. The full evaluation report is available as the Group's Conference Room Paper 262, and an executive summary is annexed to this Progress Report.

6. The Ad Hoc Group noted that the first year of GSETT-3 has successfully demonstrated the feasibility of establishing and operating an International Seismological Monitoring System, based on the concepts described in CD/1254. It has further demonstrated that the expected capabilities of the system can be achieved in areas where the network is complete and when IDC processing and analysis have been properly optimized and calibrated.

7. The participation in GSETT-3 has steadily increased, and by the end of 1995 the GSETT-3 network comprised 41 primary stations (12 more than in January 1995) and 76 auxiliary stations (32 more than in January 1995). Thirty primary and 33 auxiliary stations are part of the envisaged IMS networks. Although the geographical distribution of stations is still uneven, GSETT-3 includes stations on all continents, including Antarctica. Forty-five countries have contributed data from seismic stations to GSETT-3 during 1995.

8. The GSETT-3 International Data Centre (IDC) has been in continuous operation during 1995, with only minor interruptions. The IDC operation has steadily improved. During the first-year of GSETT-3, the GSETT-3 IDC has demonstrated the viability and effectiveness of all major concepts envisaged in CD/1254. This includes:

-- acquisition and archiving the volume of seismic data that is anticipated for an International Monitoring System (IMS) to be established under a CTBT

-- routinely analyzing this large volume of data in a timely manner

-- producing and distributing a set of defined products that are usable and useful for seismological monitoring and system evaluation.

It must be realized, however, that the GSETT-3 IDC is an experimental facility, and that prototyping and improvement of certain elements of the system continue. In particular, there is a need for further development to improve the quality of automated processing, improve event location and depth, compute additional and improved event characterization parameters, and provide user-friendly methods to report IDC products.

9. During 1995, the GSETT-3 IDC reported 20,224 seismic events in the Reviewed Event Bulletin (REB). This bulletin represents a data reduction by as much as a factor of 10,000 compared to the raw data. Using the data dissemination tools provided by the IDC, GSETT-3 participants readily selected and retrieved subsets of the raw data and the signal and event parameters that they used to, among other things, complete technical analyses presented at this session.

10. The observed GSETT-3 detection capability during 1995 has been in agreement with theoretical predictions. The global 90 per cent detection threshold has improved from magnitude 4.6 to 4.2 during the year, primarily due to the addition of seismic stations in areas previously only sparsely covered. In regions of the world for which the planned GSETT-3 primary network is nearly complete, the network detects events with a magnitude of 3.5-4.0 with high probability.

11. The location capability demonstrated during GSETT-3 varied globally due to inhomogeneous coverage by GSETT-3 primary and auxiliary stations. For areas where coverage by both types of stations approached the GSETT-3 network plan, two-thirds of REB events of magnitude 4 and larger had a location uncertainty of 1,000 square kilometres or less. For areas poorly covered, the corresponding figure was one quarter. The Ad Hoc Group noted that accurate depth estimation remained an area of concern during the first year of GSETT-3. The Group expects that reliable depth estimation will require further attention in the future IMS, and notes that supplementary data from national networks will help calibrate the IDC depth estimation procedures.

12. The Ad Hoc Group noted that the location capabilities observed so far are those of a system that does not yet have all the envisaged seismograph stations and is not yet calibrated. The Group agreed that improved network coverage and calibration is a prerequisite to achieve a location accuracy of 1,000 square kilometres or better at event magnitude 4 and above. Calibration will therefore be a major goal in the further work of the Group. Close cooperation between the IDC and National Data Centers (NDCs) would be helpful in addressing this problem. The Ad Hoc Group noted, however, that for events of magnitude below 4, a location accuracy of 1,000 square kilometres or better may not be generally achieved, even with calibration.

13. The operation of stations and NDCs during GSETT-3 has in general been integrated with special monitoring agencies, national geophysical

institutes and universities, some of which are already funded for other work, and it is therefore difficult to accurately estimate their cost. However, the experiences generally confirm earlier estimates. On the other hand, more precise figures have been given for the GSETT-3 IDC, for which the funding is focused on the nuclear treaty monitoring problem. The capital investment, including research and development, of the IDC for seismic processing has been about US$ 50 million, which includes new investment of about US$ 3 million during 1995. The costs for seismic operations and maintenance during 1995 were about US$ 7 million.

14. The Group also reviewed the current status and future plans for GSETT-3 and the GSE. A detailed description of the current GSETT-3 network is provided in Annex 2, based on information provided by the Working Group on Planning. Annex 3 contains a summary report on the GSETT-3 operations provided by the Working Group on Operations.

15. In broad outline, future plans for the GSETT-3 system are first to complete integration of the system functions envisioned by the Group, and then to refocus efforts on improving the quality and operational readiness of the system. In particular, new software for automatic phase association and calculation of event characterization parameters will be implemented at the GSETT-3 IDC, with the products made available to participants. In this regard NDCs are encouraged to cooperate with the GSETT-3 IDC in sharing and comparing region-specific knowledge and software that might be useful for calculation of event characterization parameters. Work will continue on optimization of the automatic signal detection systems at the GSETT-3 IDC. In addition, region-specific calibration of event location, depth and magnitude will begin, with the GSETT-3 IDC taking advantage of the calibration information provided by NDCs. Key elements of the system, starting with the automated waveform acquisition software, will be documented and made more robust. The important task of training of international staff at the GSETT-3 IDC will continue.

16. The continued evaluation work will focus on topics which still need improvement. Particular attention will be focused on evaluation of the planned improvements to GSETT-3 operations outlined in paragraph 15.

17. The GSETT-3 experience has demonstrated that National Data Centers (NDCs) play a critical role in the operation and maintenance of reliable stations and communication links as well as in contributing to system development and evaluation. NDCs are encouraged to continue to provide input and support to the further evaluation work, and guidelines in this regard have been given by the Working Group on Evaluation.

18. The Ad Hoc Group noted with appreciation the work carried out by a number of countries in the EUROBULL experiment, which is an effort to compile a high quality and homogeneous European seismological bulletin that would provide a useful reference in the evaluation work.

19. An important remaining task for the Ad Hoc Group is to maintain and develop the extensive investments made in seismic stations worldwide and in the IDC prior to and during GSETT-3. To deliver those facilities in an operational mode to the envisaged Preparatory Commission would be a valuable contribution to the establishment of the IMS in a cost-effective way.

20. Taking into account the tasks and further plans outlined in this Progress Report, the Ad Hoc Group recommends the continuation of GSETT-3 until the envisaged Preparatory Commission assumes responsibility, including financing for the work on establishing the International Monitoring System. The Group agreed that in the future the GSETT-3 network should be modified gradually to approach the envisaged IMS network. At the same time, participating States should at least ensure the transmission of data directly from stations or through the NDCs to the GSETT-3 IDC from their stations participating in GSETT-3 and envisaged to be incorporated in the IMS.

21. The Group further recommends that the GSETT-3 IDC begin using the infrastructure developed for GSETT-3 and the experience gained from it, to support integration of other monitoring technologies envisaged for the IMS. The resulting analyses could be reflected in the GSETT-3 IDC bulletins and products so that this information together with raw data, is available to experts from all IMS technologies.

22. The Group took note of national investigations which demonstrated the synergy that could be achieved between seismic, hydroacoustic and infrasound observations. In particular, the Group noted that the inclusion of hydroacoustic data in GSETT-3 could contribute to significantly improved analysis of seismic events in oceanic areas.

23. The possibility of convening regional workshops in Africa and South East Asia is being considered. In this connection, the Group agreed that another remaining task is to increase the knowledge about seismic monitoring and the operation of a global monitoring system among scientists around the world. To have knowledgeable experts available in many countries is a prerequisite to obtaining a credible global verification system. GSETT-3 could, in this perspective, be looked upon as a large, global training exercise in which all countries can participate, especially in the operation, calibration and evaluation.

24. The Ad Hoc Group suggests that its next session, subject to approval by the Conference on Disarmament, should be convened from 20 through 24 May 1996. A draft work programme for the next session is presented in Annex 4. The work programme will be tailored to meet as much as practicable the information needs of the Ad Hoc Committee on a Nuclear Test Ban and its Working Group on Verification.

ANNEX 1

EVALUATION OF THE FIRST FULL YEAR OF GSETT-3
Executive Summary

The Working Group on Evaluation (WGE) visited the prototype International Data Centre (IDC) in January 1996 to prepare its 3rd and comprehensive Evaluation Report covering the first full year (from 1 January to 31 December 1995) of the Group of Scientific Experts (GSE) Third Technical Test (GSETT-3). This evaluation took advantage of many national contributions presented during GSE sessions, National Data Centre (NDC) evaluation reports submitted to the IDC and regular IDC Performance Reports, and was completed with full GSE input during the 43rd GSE session in February 1996.

GSETT-3 Status

At the end of 1995, the GSETT-3 primary network consisted of 41 stations (12 more than in January 1995), and the auxiliary network consisted of 76 stations (nearly unchanged since mid-1995). The Revised Event Bulletins (REB) were using data from about 70 stations on a daily average. The primary network, at the end of 1995, had not reached the envisaged 60 stations, and there remained significant gaps in primary station coverage in Africa and Asia.

Many stations participating in GSETT-3 did not meet the technical standards that had been established for stations in the IMS (CD/1211). It is recommended that the GSE undertake a thorough review, on the basis of GSETT-3 experience, of the technical standards to be adopted for final IMS seismic stations. There is little merit in having a high standard if it cannot be met by most current stations, and if stations of lesser standard can make significant and acceptable contributions to the IMS.

Near the end of 1995, some of the primary stations were reaching the target of 95 per cent data availability set for GSETT-3. However, a target of 99 per cent data availability set for the primary stations of the IMS will require a significant hardening of the stations against lightening strikes and power outages, a ready supply of spare components, and technical staff ready to make repair trips to remote stations at short notice. These factors must be taken into account in any realistic costing of the seismic stations in the IMS.

At the end of 1995, all primary stations data communications to the IDC were served by just eight NDC-IDC links. Some of these links from large countries carried data from many stations; two of them (from Norway and USA) carried data collected at relay centres, from countries mainly in Europe and the southern hemisphere, respectively. This represents a very cost-effective use of international communications, and should be envisaged also for the IMS communication network.

Both stations-NDC and NDC-IDC communication links are quite reliable. Problems that have been encountered during the first year of GSETT-3 are considered amenable to solutions that will guarantee a very high percentage of availability. New satellite communication technology could significantly reduce the communication costs in the forthcoming years.

Response time and data availability at auxiliary stations were not always satisfying in 1995. Some changes in both the NDC's AutoDRM implementation, and the IDC requesting procedures could improve this situation.

To date, fifty countries are committed to participating in GSETT-3. During the first year of the test, it has become increasingly clear that NDCs are at present not working in an operational mode - that is, they are for the most part working normal office hours and have a hardware maintenance system which guarantees repair to equipment only within a certain time. This mode of operation can result in large outages due to failures within the NDC systems. If the eventual IMS requires a high level of operational capability, NDC responsibilities will need to be defined more formally, and budgetary allowance will have to be made for equipment backup and call-out, and overtime payment for NDC and station staff. This will have to be taken into account when estimating costs of the IMS system.

NDCs are becoming more active in the evaluation of GSETT-3 (18 of them were sending supplementary data to the IDC, in late 1995), but it is very important that they be more closely involved during 1996 especially in three areas of study: comparison of NDC signal detectors with IDC detection systems for primary stations; comparison of supplementary data and IDC location for specific territories; and provision of regional travel times and amplitude/distance curves for calibration studies.

A quality assurance evaluation of the IDC was performed in January 1996. The chief conclusion was that the IDC has demonstrated, during the first year of GSETT-3, the viability and effectiveness of all major concepts. There were certain key problems however which have precluded full realisation of the potential of these concepts.

A fundamental part of the concept of this system is to automate the procedures as far as possible. In fact, the degree of automatic processing at the IDC was high in 1995: functions such as communications, data archiving and request message handling and other routine operations were fully automatic. However, the results of automatic data processing have not yet reached, during 1995, that level of quality that was initially expected. Automatic detection, association and generation of seismic events produce many false events if the system is run at the current detection/location threshold. This has resulted in a need for extensive analyst review of automatically determined solutions, to produce the required high percentage of valid events with accurate locations.

As a consequence, there is a specific need for more emphasis on seismic analysts work, which can provide valuable information regarding the shortcomings in the automatic procedures, and provide the necessary feedback for evaluation and tuning of the system. Also, analyst workload is considerably increased during earthquake sequences, and in that case target distribution delays for the REB can only be reached if the quality of analyst review is reduced for significant time periods. This may indicate that consideration should be given to hiring more analysts for the eventual IMS than are currently hired at the IDC. As the degree of automation and tuning of the system increases, the need for human interaction will decrease again at a later stage of IMS.

Increased staffing at the IDC could also allow the allocation of more time to developing, implementing and testing more thoroughly software modifications, and for improving seismological processing.

The concept of one IDC has proven effective during the first year of GSETT-3, though some attention should still be given to increasing security against data loss and unauthorised access. Back-up systems must be established for critical components of the system, such as mass storage devices and communication links. Data authentication should be tested and evaluated more extensively than has been done until now. Some software components, including the inter-process communication and the database programs, suffered overload and/or reliability problems.

The large number of potential seismic events produced by the automatic association of detections from the primary network generates a very large number of automatic requests for auxiliary station data, most of them for events that are later rejected by the analyst. Severely mislocated events will generate useless automatic auxiliary data requests. Events missed in the automatic event lists and added to the REB during analyst review will not benefit from any auxiliary data. This suggests that consideration should be given to changing the timing of the initial auxiliary data requests, to follow analyst review of the Automatic event List. This will significantly reduce the numbers and costs of auxiliary data requests, but will increase the workload on the analysts. A test of these modified procedures should be made as soon as possible.

The contribution of the international experts working at the IDC since the beginning of the experiment has been invaluable. Ten visiting experts were working at the IDC in December 1995, and a total of fifteen experts have visited the IDC during the first year of GSETT-3. Experience showed that a 6 to 12 months time period is necessary to fully train a computer-literate expert in any of the major IDC operations.

Comprehensive technical documentation of all procedures and software/hardware implementation was judged an important part of GSETT-3. However this documentation is not yet complete.

GSETT-3 Products

The IDC has demonstrated, during the first year of GSETT-3, the feasibility of providing a wide range of event bulletins, raw data and derived products to the NDC users, through its subscription service, automated AutoDRM data access, the Worldwide Web (WWW) interface.

Reviewed Event Bulletins (REBs) as well as automatic event lists are produced on a routine basis, and they are usually generated on time, except in cases of hardware/software problems, or in cases of large earthquake sequences. Minor problems with data formats have been fixed during 1995.

The IDC AutoDRM suffered, in 1995, from some unacceptably large response delays. Also, all features planned for the AutoDRM and subscription mechanisms are not yet implemented.

GSETT-3 Seismological capabilities

Detection thresholds and location capabilities of the GSETT-3 system in late 1995 were experimentally derived through comparisons of IDC bulletins to supplementary data or to recognized international reference bulletins.

The results showed that GSETT-3 detection capability has not evolved much during the second half of 1995, and that it is in agreement with theoretical expectations. The worldwide mean 90 per cent detection threshold (for 3 P phases or more) was at a bodywave magnitude of about 4-4.2, but it was very uneven, reflecting the sparse and uneven primary station coverage. In mid-1995, the detection thresholds were at bodywave magnitudes of 3.6 or less in most of North America, North-Western Europe and Australia; they were below 4.2 for nearly all inland regions in the northern hemisphere. In most of the southern hemisphere oceans, detection thresholds ranged between 4.2 and 4.6. The simulation results for the December 1995 network configuration showed no big differences with June, except in Central Asia, where detection thresholds close to 3.6 are obtained, and South America, where the thresholds are below 4.2 nearly everywhere.

Location capability also varied strongly worldwide, the auxiliary station network being even more unevenly distributed than the primary network, with concentrations mostly in Europe, North America and Australia. At the end of 1995, only 18 per cent of the events in the REB had confidence ellipses

with areas less than 1,000 square kilometres (this figure was nearly unchanged since June 1995). Experimental and theoretical results presented during the 42nd GSE session in November 1995 have demonstrated that azimuth coverage at regional distance is a very important factor for accurate location capability. At least 5 of 8 octants around an event location must be covered by seismic stations in order to reach confidence ellipse areas below 1,000 square kilometres.

Thus, the detection and location capabilities observed so far are those of an untuned and non-calibrated system. The current GSETT-3 experiment has not yet obtained the best possible performance from the system which has been established. Tuning of all automatic processing stages (including detection, association and event definition), and introduction of region-specific wave propagation and attenuation models is needed in order to improve the seismological results. This should be a major goal of GSETT-3 during the coming months, for which significant NDC input will be required.

Future Evaluation Work

Recognizing that the current GSETT-3 is an experimental system, and that the WGE could only devote limited effort to the evaluation task, formal quality control procedures could not be employed. It is recommended, for the benefit of the future IMS, that external auditing be performed, and that comprehensive quality assurance procedures be incorporated into plans for the future IDC.

The WGE will continue its evaluation work, focusing on topics which still need improvement. Concerning the IDC operations, these topics include usage of data from auxiliary stations, tuning of all automatic procedures, improved computation of depth and source characterization parameters, and calibration through the introduction of region-specific travel time and attenuation models. In particular, the effects of the installation of new detection processing and phase association software will be carefully monitored.

The WGE encourages the NDCs to interact more with the IDC, both for routine station monitoring operations, and for contributing to the tuning and calibration tasks. Questionnaires will be distributed at various times to the NDCs in order to get some feedback on specific evaluation topics.

Improvement of GSETT-3 seismological capability will be further monitored and quantified, using for example regional bulletins for Europe and Scandinavia. Network simulation programmes will be further used and improved.

ANNEX 2

Table 1: Status of GSETT-3 Station and Gamma Data Commitments as of 23 February 1996

Country	GSETT-3 Primary Stations Envisaged by GSE	GSETT-3 Auxiliary Stations Offered	Station Commitment Status	Data Available to IDC	Gamma Data Committed/ Provided to IDC
Argentina	1	2	committed	1994/1996/7	yes/no
Armenia	0	1	committed	1996	-
Australia	5	12	committed	1994	yes/yes
Austria	0	1	lacking	unknown	-
Belgium	0	0	not applicable	not applicable	yes/no
Bolivia	1	-	committed	1995	-
Botswana	1	-	lacking	unknown	-
Brazil	1	2	committed	1994/1996	yes/no
Bulgaria	0	1	committed	1996	yes/no
Canada	6	18	committed	1994	yes/yes
Cen. Afr. Republic	1	-	committed	1994	-
Chile	0	1	committed	1995	yes/no
China	3	0	committed	1995/1996	yes/no
Colombia	1	0	committed	1996	yes/no
Cook Islands	0	1	committed	1994	-
Costa Rica	0	1	committed	1995	yes/no
Czech Republic	0	1	committed	1994	yes/no
Denmark	0	1	committed	1996	yes/yes
Egypt	1	0	lacking	unknown	-
Ethiopia	0	1	committed	1995	-
Fiji	0	1	committed	1996	-
Finland	1	2	committed	1994	yes/yes
France	1	0	committed	1995	yes/yes
Germany	1	9	committed	1994	yes/yes
Hungary	0	1	committed	1994	yes/no
Iceland	0	1	committed	1995	-
India	1	0	committed	unknown	-
Indonesia	1	-	lacking	unknown	-
Iran, Islamic Rep. of	1	2	committed	1996	yes/no
Israel	0	4	committed	1995/1996	yes/yes
Italy	0	2	committed	1994	yes/yes
Ivory Coast	1	-	committed	1995	-
Japan	1	7	committed	1994/1996	yes/yes
Kazakhstan	1	3	committed	1996	-
Kenya	1	-	lacking	unknown	-
Republic of Korea	1	-	lacking	unknown	-
Mexico	1	2	lacking	unknown	-
Mongolia	1	1	committed	1995/1996	-
Namibia	0	1	committed	1995	-
Netherlands	0	1	committed	1994	yes/no
New Zealand	0	1	committed	1994	yes/yes

Country	GSETT-3 Primary Stations Envisaged by GSE	GSETT-3 Auxiliary Stations Offered	Station Commitment Status	Data Available to IDC	Gamma Data Committed/ Provided to IDC
Norway	3	1	committed	1994/1996	yes/yes
Pakistan	1	1	committed	1995/1996	-
Papua New Guinea	1	-	committed[1]	1995	-
Paraguay	1	-	committed	1994	-
Peru	0	1	committed	1996	yes/no
Philippines	0	1	committed	1995	-
Poland	0	1	committed	1996	yes/yes
Portugal	0	1	committed	-	-
Romania	0	1	committed	1996	yes/yes
Russian Federation	5	5	committed	1994/1996	yes/yes
Seychelles	0	1	committed	1995	-
Solomon Islands	0	1	committed	1995	-
South Africa	1	2	committed	1994/1996	yes/yes
Spain	1	2	committed	1995	yes/yes
Sweden	1	0	committed	1995	yes/yes
Switzerland	0	2	committed	1995/1996	yes/yes
Thailand	1	-	committed	1995	-
Tunisia	1	-	lacking	unknown	-
Turkey	1	-	committed	unknown	-
Turkmenistan	1	-	committed	1995	-
Ukraine	1	1	committed	1995/1996	yes/no
United Kingdom	0	3	committed	1994/1996	yes/yes
United States	7	11	committed	1994	yes/yes
Venezuela	0	1	committed	1995	-
Western Samoa	0	1	committed	1994	-
Zambia	0	1	committed	1995	-
TOTAL (Committed)	**60(53)**	**119 (116)**			**34/20**

1. Envisaged GSETT-3 Primary station currently used as a GSETT-3 auxiliary station.

Table 2: GSETT-3 Stations

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Argentina							
Paso Flores	PLCA	α	3-C	-40.731	-70.550	yes	yes
Coronel Fontana	CFA	β	3-C	-31.607	-68.239	no	yes
Ushuaia	USHA	β	3-C	-54.800	-68.300	no	yes
Armenia							
Garni	GNI	β	3-C	40.050	44.720	no	yes
Australia							
Alice Springs	ASAR	α	array	-23.666	133.904	yes	yes
Mawson, Antarctica	MAW	α	3-C	-67.604	62.871	yes	yes
Stephens Creek	STKA	α	3-C	-31.882	141.592	yes	yes
Warramunga	WRA	α	array	-19.943	134.339	yes	yes
Woolibar	WOOL	α	3-C	-31.073	121.678	yes	no
Armidale	ARMA	β	3-C	-30.420	151.628	yes	no
Casey	CSY	β	1-C	-66.289	110.529	yes	no
Charters Towers	CTA	β	3-C	-20.088	146.254	yes	yes
Fitzroy Crossing	FITZ	β	3-C	-18.103	125.643	yes	yes
Forrest	FORT	β	1-C	-30.779	128.059	yes	no
Meekatharra	MEEK	β	1-C	-26.614	118.536	yes	no
Mount Isa	QIS	β	1-C	-20.558	139.605	yes	no
Narrogin	NWAO	β	3-C	-32.927	117.233	yes	yes
Roma	RMQ	β	1-C	-26.489	148.755	yes	no
Toolangi	TOO	β	3-C	-37.571	145.491	yes	no
Warburtan	WARB	β	3-C	-26.184	126.643	yes	no
Young	YOU	β	1-C	-34.278	148.382	yes	no
Austria							
Molln	MOA	β	3-C	47.850	14.266	no	no
Bolivia							
La Paz	LPAZ	α	3-C	-16.288	-68.131	yes	yes

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Botswana							
Lobatse	LBTB	α	3-C	-25.015	25.597	no	yes, as auxiliary
Brazil							
Brasilia	BDFB	α	3-C	-15.642	-48.015	yes	yes
Pitinga	PTGA	β	3-C	-3.060	-60.000	no	yes
Rio Grande do Norte	RGNB	β	3-C	-6.910	-36.950	no	yes
Bulgaria							
Vitosha	VTS	β	3-C	42.618	23.238	no	no
Canada							
Lac du Bonnet	ULM	α	3-C	50.250	-95.875	yes	yes
Mould Bay	MBC	α	3-C	76.242	-119.360	yes	yes, as auxiliary
Schefferville	SCH	α	3-C	54.817	-66.783	yes	yes
Waterton Lakes	WALA	α	3-C	49.059	-113.912	yes	no
Whitehorse	WHY	α	3-C	60.660	-134.881	yes	no
Yellowknife	YKA	α	array	62.493	-114.605	yes	yes
Bella Bella	BBB	β	3-C	52.185	-128.113	yes	yes
Caledonia Mtn.	LMN	β	3-C	45.852	-64.806	yes	no
Dawson City	DAWY	β	3-C	64.066	-139.391	yes	no
Dease Lake	DLBC	β	3-C	58.417	-130.060	yes	yes
Deer Lake	DRLN	β	3-C	49.256	-57.504	yes	no
Edmonton	EDM	β	3-C	53.222	-113.350	yes	no
Eldee	EEO	β	1-C	46.641	-79.073	yes	no
Fort Churchill	FCC	β	3-C	58.761	-94.087	yes	no
Glen Almond	GAC	β	3-C	45.703	-75.478	yes	no
Inuvik	INK	β	3-C	68.307	-133.520	yes	yes
Iqaluit	FRB	β	3-C	63.747	-68.547	yes	yes
La Malbaie	LMQ	β	3-C	47.548	-70.327	yes	no
Pac. Geoscience	PGC	β	3-C	48.650	-123.451	yes	no

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Pemberton	PMB	β	3-C	50.520	-123.073	yes	no
Penticton	PNT	β	3-C	49.317	-119.617	yes	no
Resolute Bay	RES	β	3-C	74.687	-94.900	yes	no
Sadowa	SADO	β	3-C	44.769	-79.142	yes	yes
Thunder Bay	TBO	β	1-C	48.647	-89.408	yes	no
Central African Republic							
Bangui	BGCA	α	3-C	5.176	18.424	yes	yes
Chile							
Rapa Nui	RPN	β	3-C	-27.160	-109.430	yes	yes
China, Peoples Republic of							
Beijing	BJT	α	3-C	40.018	116.168	yes	yes, as auxiliary
Hailar	HIA	α	3-C	49.267	119.742	no [1]	yes
Lanzhou	LZH	α	3-C	36.087	103.844	no	yes
Colombia							
El Rosal	ROSC	α	3-C	4.860	-74.330	no	yes
Cook Islands							
Rarotonga	RAR	β	3-C	-21.213	-159.773	yes	yes
Costa Rica							
Las Juntas de Abangares	JTS	β	3-C	10.290	-84.950	yes	yes
Czech Republic							
Vranov	VRAC	β	3-C	49.311	16.596	yes	yes
Denmark							
Søndre Strømfjord	SFJ	β	3-C	67.050	-50.300	no	yes
Egypt							
LUXESS	LXAR	α	array	26.000	33.00 0	no	yes
Ethiopia							
Addis Ababa	AAE	β	3-C	9.029	38.766	yes	yes
Fiji							
Monasavu	MSVF	β	3-C	-17.750	178.050	no	yes

1. Data currently received at the IDC, but not yet used in processing.

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Finland							
FINESS	FINES	α	array	61.444	26.077	yes	yes
Kangasniemi	KAF	β	3-C	62.113	26.306	yes	no
Ylistaro	VAF	β	3-C	63.042	22.672	yes	no
France							
Lormes	LOR	α	3-C	47.268	3.859	yes	no
Germany							
GERESS	GERES	α	array	48.845	13.702	yes	yes
Berggiesshübel	BRG	β	3-C	50.875	13.947	yes	no
Black Forest	BFO	β	3-C	48.331	8.330	yes	no
Bochum	BUG	β	3-C	51.446	7.264	yes	no
Clausthal-Zellerfeld	CLZ	β	3-C	51.843	10.374	yes	no
Collm	CLL	β	3-C	51.310	13.000	yes	no
Fürstenfeldbruck	FUR	β	3-C	48.164	11.277	yes	no
Gräfenberg	GRFO	β	3-C	49.692	11.205	yes	no
Moxa	MOX	β	3-C	50.646	11.616	yes	no
Taunus	TNS	β	3-C	50.224	8.449	yes	no
Hungary							
Piszkes	PSZ	β	3-C	47.918	19.895	yes	no
Iceland							
Borgarnes	BORG	β	3-C	64.750	-21.330	yes	yes
India							
Gauribidanur	GBA	α	array	13.604	77.436	no	yes
Indonesia							
Jakarta	PACI	α	3-C	-6.593	106.910	no	yes, as auxiliary
Iran, Islamic Republic of							
Tehran	THR	α	3-C	35.818	51.393	no	yes
Kerman	KRM	β	3-C	30.280	57.070	no	yes
Masjed-e-Solayman	MSN	β	3-C	31.930	49.300	no	yes

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Israel							
Bar Giyora	BGIO	β	3-C	31.722	35.092	yes	no
Parod	PARD	β	array	32.550	35.260	no	yes
Atar Shivta	ATR	β	3-C	30.970	34.630	no	no
Eilath	MBH	β	3-C	29.790	34.910	no	yes
Italy							
L'Aquila	AQU	β	3-C	42.354	13.405	yes	no
Villasalto	VSL	β	3-C	39.496	9.378	yes	no
Ivory Coast							
Dimbroko	DBIC	α	3-C	6.670	-4.856	yes	yes
Japan							
Matsushiro	MJAR	α	array	36.543	138.207	yes	yes
Aobayama	AOB	β	3-C	38.250	140.850	no	no
Chichijima	OGS	β	3-C	27.060	142.200	yes	yes
Hachijojima	HCH	β	3-C	33.120	139.800	no	yes
Ishigakijima	ISG	β	3-C	24.380	124.230	no	no
Kaminokuni	KKJ	β	3-C	41.780	140.180	no	no
Shiraki	SHK	β	3-C	34.530	132.680	no	no
Tsukuba	TSK	β	3-C	36.210	140.101	yes	no
Kazakhstan							
Aktubinsk	AKT0	α	3-C	50.434	58.018	no	yes
Borovoye	BRVK	β	array	53.058	70.283	no	yes
Kurchatov	KURK	β	array	50.715	78.621	no	yes
Makanchi	MAK	β	3-C	46.808	81.977	no	yes
Kenya							
Nairobi	KMBO	α	3-C	-1.274	36.804	no	yes
Korea, Republic of							
Wonju	KSRS	α	array	37.450	127.920	no	yes
Mexico							
To be defined	XMEX	α	3-C	18.000	-96.000	no	no

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Chilapa	CHAM	β	3-C	17.000	-99.000	no	no
Iguala	IGUM	β	3-C	19.000	-100.000	no	no
Mongolia							
Javkhlant	ALFM	α	3-C	47.991	106.766	no	yes
Ulaan-Baatar	ULN	β	3-C	47.520	107.030	yes	no
Namibia							
Tsumeb	TSUM	β	3-C	-19.202	17.584	yes	yes
Netherlands							
Heimansgroeve	HGN	β	3-C	50.764	5.932	yes	no
New Zealand							
South Karori	SNZO	β	3-C	-41.310	174.705	yes	no
Norway							
ARCESS	ARCES	α	array	69.535	25.506	yes	yes
NORSAR	NAO	α	array	60.824	10.832	no	yes
Spitsbergen	SPITS	α	array	78.178	16.370	yes	yes, as auxiliary
NORESS	NORES		array	60.735	11.541	yes, as a substitute for NAO	no
Jan Mayen Island	JMI	β	3-C	70.920	-8.720	no	yes
Pakistan							
Pari	PKAR	α	array	33.050	73.252	no	yes
Nilore	NIL	β	3-C	33.650	73.250	yes	no
Papua New Guinea							
Port Moresby	PMG	α	3-C	-9.409	147.154	yes, as β station	yes, as auxiliary
Paraguay							
Villa Florida	CPUP	α	3-C	-26.331	-57.329	yes	yes
Peru							
Nana	NNA	β	3-C	-11.990	-76.840	no	yes
Philippines							
Davao	DAV	β	3-C	7.090	125.570	yes	yes

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Poland							
Suwalki	SUW	β	3-C	54.001	23.182	no	no
Portugal							
To be defined		β	3-C			no	no
Romania							
Muntele Rosu	MLR	β	3-C	45.492	25.944	no	yes
Russian Federation							
Khabaz	KBZ	α	3-C	43.729	42.898	yes	yes
Norilsk	NRI	α	3-C	69.400	88.100	yes	yes
Peleduy	PDY	α	3-C	59.633	112.700	yes	yes
Ussuriisk	USK	α	3-C	44.283	132.083	no	yes
Zalesovo	ZAL	α	3-C	53.940	84.805	yes	yes
Arti	ARU	β	3-C	56.430	58.563	yes	yes
Kislovodsk	KIV0	β	array	43.956	42.695	yes	yes
Obninsk	OBN	β	3-C	55.117	36.600	yes	yes
Urgal	URG	β	3-C	51.099	132.364	no	yes
Zilim	UFA	β	3-C	53.850	57.050	no	yes
Seychelles							
Mahe	MSEY	β	3-C	-4.61	55.49	yes	no
Solomon Islands							
Honiara	HNR	β	3-C	-9.432	159.47	yes	yes
South Africa							
Boshof	BOSA	α	3-C	-28.614	25.556	yes	yes
Silverton	SLR	β	3-C	-25.740	28.280	no	no
Sutherland	SUR	β	3-C	-32.380	20.810	no	yes
Spain							
Sonseca	ESDC	α	array	39.677	-3.962	yes	yes
San Pablo de los Montes	PAB	β	3-C	39.546	-4.348	yes	no
Taburiente	TBT	β	3-C	28.679	-17.913	yes	no

Station Name (in alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Sweden							
Hagfors	HFS	α	array	60.134	13.697	yes	yes, as auxiliary
Switzerland							
Alpnach	APL	β	3-C	46.950	8.243	yes	no
Davos	DAVOS	β	3-C	46.840	9.790	no	yes
Thailand							
Chiang Mai	CMAR	α	array	18.458	98.943	yes	yes
Tunisia							
Thala	THA	α	3-C	35.560	8.700	no	yes
Turkey							
Belbashi	BRTR	α	array	39.870	32.790	no	yes
Turkmenistan							
Alibek	ABKT	α	array	37.930	58.199	yes	yes
Ukraine							
Malin	AKASG	α	array	50.600	29.400	no	yes
Kiev	KIEV	β	3-C	50.694	29.208	yes	no
United Kingdom							
Eskdalemuir	EKA	β	array	55.333	-3.159	yes	yes
Wolverton	WOL	β	3-C	51.313	-1.223	no	no
Ascension Island	ASCN	β	3-C	-7.950	-14.380	yes	no
United States							
Lajitas	TXAR	α	array	29.334	-103.667	yes	yes
Lisbon	LBNH	α	3-C	44.240	-71.926	yes	no
Mount Ida	MIAR	α	3-C	34.546	-93.573	yes	no
North Pole	NPO	α	3-C	64.771	-146.887	yes	yes
Pinedale	PDAR	α	array	42.767	-109.558	yes	yes
Pinon Flats	PFO	α	3-C	33.609	-116.455	yes	yes
Vanda, Antarctica	VNDA	α	3-C	-77.514	161.846	yes	yes

Station Name (In alphabetical order)	Code	Type	Station Type	Latitude	Longitude	Data used by IDC by 23 February 1996	In envisaged IMS network
Albuquerque	ALQ	β	3-C	34.946	-106.457	yes	yes
Black Hills	RSSD	β	3-C	44.120	-104.036	yes	no
Blacksburg	BLA	β	3-C	37.211	-80.421	yes	no
Dugway	DUG	β	3-C	40.195	-112.816	yes	no
Elko	ELK	β	3-C	40.745	-115.239	yes	yes
Ely	EYMN	β	3-C	47.947	-91.508	yes	no
Mina	MNV	β	3-C	38.433	-118.153	yes	no
Newport	NEW	β	3-C	48.263	-117.120	yes	yes
Tucson	TUC	β	3-C	32.310	-110.785	yes	no
Tuckaleechee Caverns	TKL	β	3-C	35.658	-83.774	yes	yes
Tulsa	TUL	β	3-C	35.911	-95.793	yes	no
Venezuela							
Santo Domingo	SDV	β	3-C	8.879	-70.633	yes	yes
Western Samoa							
Afiamalu	AFI	β	3-C	-13.909	-171.779	yes	yes
Zambia							
Lusaka	LSZ	β	3-C	-15.277	28.188	yes	yes

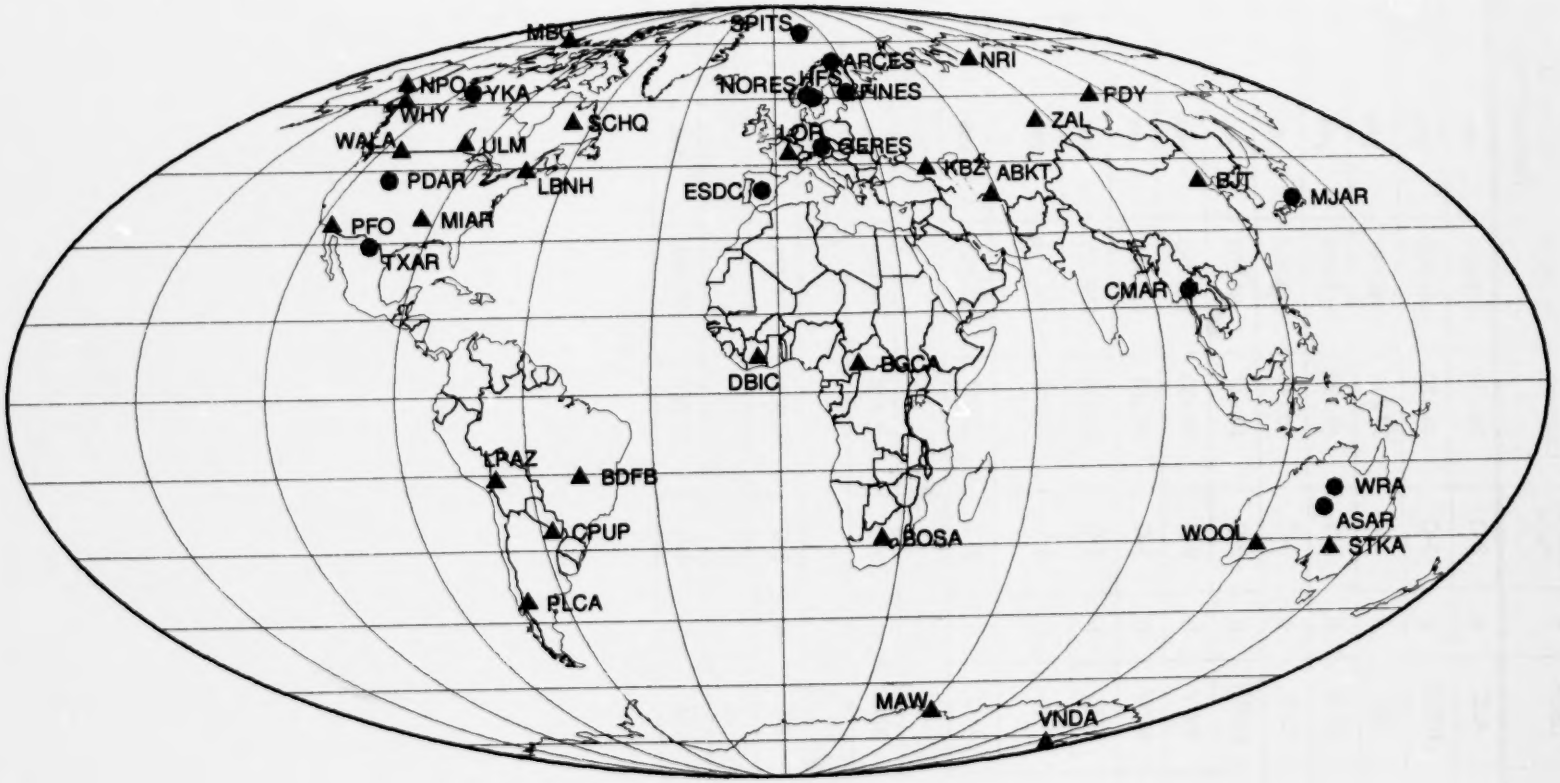

Fig. 1. Primary (Alpha) stations used by the IDC as of 23 February 1996. Arrays are shown as filled circles and three-component stations as filled triangles.

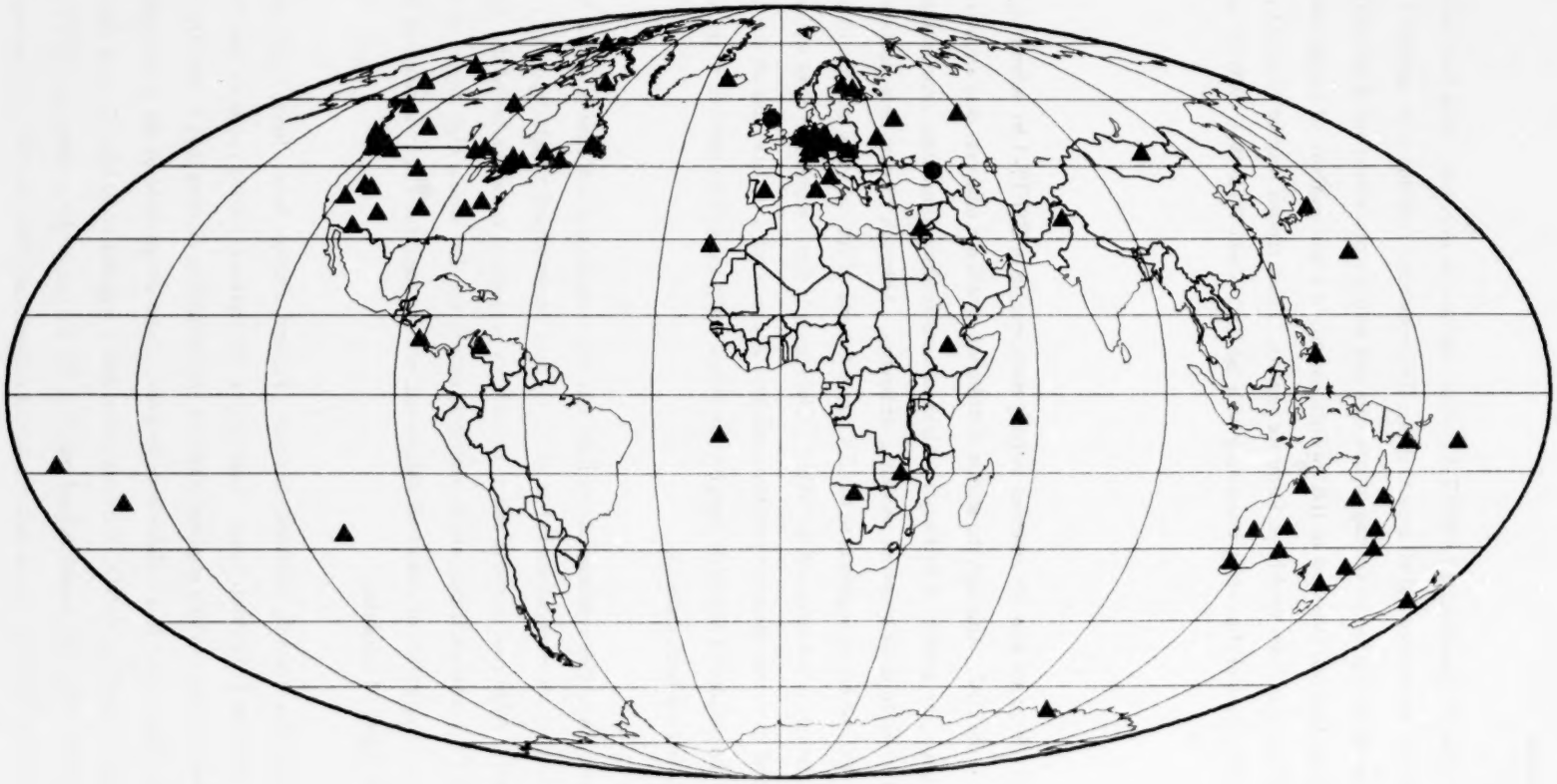

Fig. 2. Auxiliary (Beta) stations that have been used by the IDC by 23 February 1996. Arrays are shown as filled circles and three- and one-component stations as filled triangles.

ANNEX 3

GSETT-3 Operations

Now in its second year of operation, the GSETT-3 system continues to improve. With time, additional stations are still being added to the system and all aspects of the IDC operations continue to be upgraded with the objective of further optimising the processing of raw data and with the production and distribution of IDC products. A detailed statistical overview of IDC operations and, to a lesser extent, of station and NDC participation, is provided in four- weekly performance reports. These reports may be retrieved electronically using the file transfer protocol (ftp) or by interacting with the IDC World-Wide Web (WWW) server on the Internet.

Status

As listed in Table 3, there are now 45 countries actively participating in GSETT-3 by submitting data to and/or retrieving data from the IDC. Although the station distribution is still not uniform, data are arriving at the IDC from every continent. The number of Primary or Alpha stations sending continuous, near-realtime data to the IDC has increased to 42 from 22 countries including Antarctica. Although 13 new Beta stations began contributing requested waveform segments to the IDC since the end of August, this increase in the number of participating Beta stations is not reflected in Table 3. The reason is that a number of Beta stations have experienced technical or communications problems and have not responded to data requests for a period of more than one month. The stations in this latter category are polled daily and will be restored to the GSETT-3 network when normal operation has been restored.

With few exceptions, dedicated communications links and data transmission software from the Alpha stations to the IDC (often through a communications hub at an NDC) have demonstrated a high degree of reliability and have performed adequately. Additional attention and or redundancy is required for a number of the Alpha and Beta stations in the GSETT-3 network if they are to contribute data to the IDC with a high degree of reliability. Further attention to the operation of almost all stations and/or communications links is required if they are to obtain a very high degree of reliability.

Eighteen NDCs (Australia, Canada, Denmark, Germany, Finland, France, Israel, Italy, Japan, New Zealand, Poland, Romania, Russian Federation, Spain, South Africa, Switzerland, United kingdom, and the United States) are now locating seismic events using regional networks and submitting Gamma data to the IDC in the form of independent seismic event lists. In a collaborative program, observations made by the Norwegian and Swedish NDCs are forwarded to the Finnish NDC for compilation into a regional event list. Gamma data submitted by NDCs are typically more than one month behind real time but are crucial for evaluating GSETT-3 and for calibrating the GSETT-3 network. These data are parsed automatically into the IDC database and are available for online access by the NDCs.

Table 3

	1 Feb 1994	20 Aug 1994	20 Feb 1995	18 Aug 1995	18 Feb 1996	Plan
Participating Nations	10	13	28	33	45	>40
Primary Stations	6	12	32	35	42	60
Auxiliary stations	13	21	44	76	77	~150
Coverage	European	Sparse Global	Global	Global	Global	Global
NDCs sending Gamma data	1	5	11	14	18	20-30
Data Volume per day to IDC	0.2 Gbytes	1.5 Gbytes	2.5 Gbytes	2.5 Gbytes	2.6 Gbytes	>5 Gbytes
Data Days per week	2	3	7	7 24hrs/day	7 24hrs/day	7 24hrs/day
REB Events/day	20	20	60	60	65	>100
REB Events Total	1,500	2,700	6,800	12,250	23,733	
IDC Staff (int'l)	27(0)	27(0)	47(9)	50(10)	53(10)	50(9)

Starting 1 January 1995, the IDC began full-scale operation seven days per week and 24 hours per day. The IDC produces automatically an Alpha Event List (AEL) based on signals detected in the realtime, continuous waveform data from Alpha stations. Beta waveform segments, which are based on AEL event locations, are then automatically retrieved and analysed and an Alpha/Beta event list (ABEL) is produced. The waveform data are interactively reviewed to produce a Reviewed Event Bulletin (REB). The target time for completing the automatic bulletins are 1 hour (AEL) and 4 hours (ABEL) after event time. The target time for the REB is two days after the end of the data day. With minor exceptions, which have been associated with either large aftershock sequences or to instabilities in a developing system, these target times have been adhered to.

There are now, on average, more than 65 events in the REBs each day. This number is not constant but has fluctuated to over 200 events per day on several datadays when large earthquakes with their consequent aftershock sequences have occurred. The extra workload required for analyst review of the large numbers of additional events has dictated that not all data on these datadays could be visually scanned for missed events. The REBs may be less complete for these periods.

Estimates of the magnitude threshold at the 90% confidence level, for detection of a seismic disturbance by three stations in the Alpha network have not changed appreciably since the last report and still ranges from mb 3.1 in northern Europe up to mb 4.7 in parts of the southern oceans. These estimates reflect the geographical distribution and detection capabilities of stations in the current Alpha network. Typical location uncertainties for events within 2000 km of the closest station are between 40 and 50 km. Completion and calibration of the station network by the use of regional, rather than globally averaged travel times, will improve the detection capability and reduce the location uncertainty.

The number of staff at the IDC is now 53 including 10 international visiting experts. International staffing and training continues to be a high priority of the Working Group on Operations. At the last GSE session responses were received to a Working Group paper inviting GSETT-3 participants to apply for positions at the IDC. Offers have since been extended to five candidates to spend up to one year at the IDC while five other candidates have been offered one month visiting fellowships. In addition, four international experts, who have spent time at the IDC, but whose particular expertise and system knowledge is currently crucial to the development of particular aspects of the IDC processing system, have been offered extensions to their secondments.

The system that the IDC is running in an operational mode is still evolutionary in nature. As such, this system will continue to change and improve as information is gathered during GSETT-3, as new analysis algorithms are developed and as existing algorithms are improved. Signal processing and automatic association of arrivals to seismic events are major components of the data processing and interpretation segment of the IDC. The signal processing modules detect seismic signals and extract features for subsequent processing and interpretation. These features include signal onset time, azimuth and slowness, polarisation parameters, amplitudes, period, signal/noise ratio and others. Based on these features, the automatic association module groups detections that appear to come from the same event, identifies the seismic phases in terms of wave type and propagation paths and locates events using theoretical Earth models.

After extensive testing and the requirement for formulation and the addition of the parametric information for the 120 or so stations currently contributing to the IDC into the operational database, the new Detection and Feature Extraction (DFX) software was installed in the operational pipeline on 22 January. The objectives of this new software package is to improve the quality control and robustness of the feature measurements, generalise the knowledge representation, facilitate the addition of new algorithms as they are developed and to maximise the consistency between results from automatic processing and analyst review.

Testing of the new Global Association(GA) software package which uses a gridded search technique for the automatic association of seismic arrivals to events, and for the location of events, has been completed. As expected, this new package has demonstrated a significant reduction in missed events in the AEL without an increase in the number of false alarms. Furthermore, GA is faster than the software it will replace for the formation of the AELs and this will reduce problems in keeping up with processing schedules during earthquake swarms, aftershocks sequences and when additional stations are added to the Alpha network. This package will be installed in the operational pipeline when operation of the DFX software has stabilised.

In addition to these two major upgrades, new releases of almost all processing software have been incorporated into the IDC processing system. These upgrades have been installed for a number of reasons including improving the operational robustness of the system, enhancing the reliability of detections for both Alpha and Beta stations and for improving magnitude estimates.

Based on operational experience, enhancements have been made to the automatic Beta data retrieval system both to ensure that data is requested for all stations within 500 kilometres of an event and to ensure that stations from which Beta data are requested have at least some possibility of having recorded the event. Beta data are currently being used to assist in constraining the location of about 60% of the events reported in the REBs. The events for which Beta data are not being used consist mainly of those which are formed during analyst review and smaller events which are not recorded by any stations in the current Beta network. The use of Beta data, together with analyst review, are the major factors in reducing location errors and in improving the quality of the REBs.

An important objective of the IDC data processing is to optimise the automatic procedures and so reduce the amount of interactive analysis. Based on the results of previous processing, new detection parameters have been determined for all Alpha stations and incorporated into the processing system. These detection parameters will be further refined at periodic intervals.

The data access facilities at the IDC continue to improve. Since the last session access facilities to the IDC database using the GSE AutoDRM and electronic mail have been upgraded. The functionality of the IDC AutoDRM has been extended so that data from the operational database, as well as the archive database, can be accessed. Waveform data may now be retrieved by NDCs almost as soon as it has been received by the IDC. The options for obtaining information by subscription have also been extended. The IDCs World Wide Web (WWW) server continues to be upgraded and its functionality expanded. A major new release of this WWW was installed in the system in November.

The GSETT-3 IDC is not providing identification on detected events but is developing event characterisation algorithms (tools) which, based on default or individual NDC supplied screening parameters, will "screen" out seismic sources which are high probability earthquakes or mining explosions, or are seismic events that are located in areas of no interest to a particular NDC. The seismic sources which are not screened are those that do not have sufficient characterisation information to permit classification or are events which are atypical of normal seismicity (population) patterns in a particular area and which may warrant further, more detailed examination. At the current stage of development these event characterisation tools are able to screen out events based on location, (ie events in areas of no interest to a particular NDC or oceanic events for which hydroacoustic characterisation information will be available in an International Monitoring System) depth, minimum and maximum magnitudes, body wave to surface wave (Mb:Ms) ratios and frequency dependent regional amplitude ratios. This event classification package, together with an initial database of event characterisation parameters compiled for a one month period during January- February 1995, has been implemented on the IDCs World Wide Web. As for other WWW implementations, NDCs are encouraged to trial this package and to provide feedback to the IDC on such factors including: is the screening done correctly? methods by which the package may be made more user friendly and what other event classification screens might be developed?

Hardware additions at the IDC include the procurement of additional Redundant Arrays of Independent Disks (RAIDs) and a mass store based on linear tape technology and with an initial capacity of 2.2 terabytes. The RAIDs will improve the reliability of critical parts of the IDC hardware infrastructure while the mass store will allow all raw data and processed products to be accessible, online, for a period of several years.

Operational Plans

In broad outline, future operational plans will be to improve all aspects of the GSETT-3 system so as to increase its robustness, to improve the quality and completeness of the GSETT-3 products and, at the same time, to reduce the interactive workload.

An important priority will be tuning of the DFX and GA processing packages. The optimisation of these packages will not only provide the largest improvements in the shortest time but their design structure is such that additional processing algorithms and knowledge based parametric information can more easily be incorporated into the processing pipeline so as to further improve the performance of the overall system.

Pilot studies using data from the Scandinavian region have demonstrated the effectiveness of using path specific, rather than average, travel times to reduce event location uncertainties. The acquisition of path specific travel times and the incorporation of these travel times into the processing pipeline as this knowledge becomes available, will remain a priority. As in previous reports, it is noted that the acquisition of this knowledge base will require the assistance of all NDCs who may assist by providing information on regional travel times and by the provision of Gamma data to the IDC.

Work will also continue on extending the functionality of the event characterisation packages It is expected that when the DFX process is tuned, robust characterisation parameters will be extracted automatically in the processing pipeline. This parametric information, which will be stored in the IDC database, will then be available for retrieval by NDCs and for input to

To optimize the use of region specific knowledge, it is planned that two panels of seismic experts be formed, with members internal and external to the GSE. The panel briefs will be to advise on methods of minimising event location and depth uncertainties, and on procedures for improving the robustness of event magnitude determinations.

An experiment will be conducted to test the alternative strategy of retrieving data from auxiliary stations. Whereas the current practice is to retrieve auxiliary data based only on the automatic event lists, this experiment will base retrieval on analyst reviewed bulletins, This approach is expected to increase the amount of useful data retrieved, particularly for events that are added by analysts or that are poorly located in automatic processing. This experiment will be conducted after a preliminary evaluation of the new phase association program, GA, has been completed.

It is anticipated that the operation of the IDC will be suspended for several days in the next six months in order to upgrade software and hardware on the operational database server, The scheduled IDC outages will be announced 2-4 weeks in advance.

The WGO will cooperate with the WGP and NDCs to begin the transition from the GSETT-3 network to the IMS network. A smooth transition will be organised to maintain the processing load on the IDC as monitoring capability is migrated to regions that are presently uncovered. The WGO will also work toward improving the reliability of stations, particularly those in the future IMS.

Annex 4

Draft work programme for the next (44th) session

1. Continued review of results from the full-scale GSETT-3 testing:

   -- IDC reports
   -- National reports by participants

2. Further evaluation of specific aspects of the GSETT-3 system and its results by the Working Group on Evaluation.

3. Discussion of modifications to the GSETT-3 network and procedures needed in the light of these experiences

4. Discussion and adoption of a plan for network calibration.

5. Presentation and review of national investigations into relevant matters

6. Discussion of future plans

7. Submission of a progress report to the Conference on Disarmament

8. Other matters